SEISMIC SAFETY & SAFETY SUB-ELEMENT OF THE COMMUNITY DEVELOPMENT ELEMENT

CITY OF SUNNYVALE
CALIFORNIA

Adopted by Resolution No. 187-93 of the Sunnyvale City Council, September 28, 1993

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PREFACE

In 1971, the California Legislature added Government Code Section 65302 to state planning laws requiring all city and county agencies to develop seismic safety and safety elements as part of their General Plans. The Seismic Safety Element is the primary means for the community to identify hazards that must be considered in planning the location, type and density of development. It must address all relevant seismic and geologic hazards as well as structural hazards and earthquake induced flooding and fires. Plans and programs for emergency preparedness and response are also included. The Safety Element must address issues such as structure fires, flooding and hazardous materials incidents.

Sunnyvale adopted its Seismic Safety and Safety Elements in 1972. In 1984, due to the considerable overlap in the required content of each document, the Seismic Safety and Safety Elements were combined into a joint sub-element. The updated and revised version was adopted by the City Council. The General Plan calls for a review and update of the Sub-Element periodically. The update was postponed after the Loma Prieta earthquake of October, 1989 to see what was learned as a result of that disaster.

The Seismic Safety and Safety Sub-Element is part of the Community Development Element of the city's General Plan. The overall purpose of this sub-element is to provide information and policy direction for the City of Sunnyvale in the areas of safety and seismic safety. This document is also used as a guideline for determining the City's role and responsibility in these areas.

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INTRODUCTION

The relatively young geological processes that have created the San Francisco Bay Area are still active today. Seismically, the city sits between two active earthquake fault systems (the San Andreas to the west and the Hayward/Calaveras to the east) and other potentially active faults. The probability that the Bay Area will experience a major earthquake by the year 2020 is approximately 67 percent.

Lying beneath Sunnyvale are thick layers of sand, gravel and clay, known as alluvium, which amplify the effects of earthquakes. Based on the damage caused in Santa Clara Valley by the 1906 earthquake and the poor performance of alluvial deposit land areas during earthquakes, this area could be subject to severe damage from an earthquake whose epicenter is nearby. Buildings of unreinforced masonry construction and older commercial buildings will likely suffer major damage.

Fire resulting from earthquake severed gas and electrical lines pose a serious danger that may cause more damage than the earthquake itself. Major fires in San Francisco after the Loma Prieta Earthquake on October 17, 1989 are recent examples.

Land subsidence has compounded the geologic and hydrodynamic problems of the area. Subsidence is caused by excessive ground water extraction. The compression of the aquifers since 1916 has lowered the northern reaches of the city 6 to 9 feet; many parts are below the mean high tide level which has lowered the discharge capability of the surrounding streams and flood control channels. The human-caused subsidence has been halted over the last three decades by an extensive water recharge and water importation program. Natural subsidence is still continuing at a much slower rate but can be dramatically intensified by earthquakes.

Santa Clara Valley is essentially an active flood plain that has been severely altered by human activity. It is still subject to periodic flooding from excessive rain and, without the protective barriers constructed along the margins of the Bay, tidal flooding. The city maintains an extensive storm drain system and the Santa Clara Valley Water District maintains the creek and flood control channels in the city.

Much of the industry in the city is dependent upon the use of hazardous materials. These materials are constantly transported into and around the city by truck, rail and pipeline. They are being stored in large quantities in above and below ground containers. Federal, state and local controls regulate the transporters and users. However, the sheer volume of the materials being handled can lead to misuse and accidents that threaten the environment and, more importantly, can take human lives even if exposure is brief.

The city is subject to other hazards of varying degrees of probability of occurrence. High winds and tornados have caused damage in the past, but pose a minimum risk to the community. The city lies in the landing pattern of Moffett Field and, during south winds, planes take off over heavily developed areas. In 1973 two planes collided over the

Sunnyvale Municipal Golf Course, and the risk of a future aircraft accident exists even though the Navy's usage of Moffett Field as a Naval Air Station ends in 1994.

The level of risk that the community is willing to accept can be expressed in a variety of ways. However it is expressed, the assessment of hazards should be designed to accommodate new information and assist in establishing a realistic balance among the community's need for safety and economic and social requirements.

Not all disasters are preventable but knowledge of the hazards and proper planning are significant measures that mitigate their effect.

PURPOSE

The purpose of this sub-element is to document seismic safety and other safety issues in Sunnyvale and establish a planning document to help guide land use decisions. This can help establish a balance between the community's need for safety with other needs such as housing, employment and transportation. Incorporating knowledge of existing safety hazards into the planning and development review process is an essential part of the process. This sub-element contains an integrated set of goals, policies and actions to guide the community decision making process in a consistent manner.

The sub-element is one of several General Plan documents that establish overall city policy. In addition, the actions taken by the city affect, and are affected by, the actions of other government agencies at federal, state, regional and county levels. Some decisions by other agencies may preempt or influence local decision-making by imposing requirements for funds, program criteria, and regulations. This document seeks to create an atmosphere of cooperation among public and private entities by explaining the goals and policies of the City of Sunnyvale.

Other sub-elements which directly address community safety are: the Water Sub-Element, the Surface Runoff Sub-Element, the Air Quality Sub-Element, the Fire Services Sub-Element and the Law Enforcement Sub-Element. Other documents indirectly related to the Seismic Safety and Safety Sub-Element are the Land Use Sub-Element and the Transportation Element. Many of these elements and sub-elements were developed or revised since 1984 when the Seismic Safety and Safety Sub-Element was written. This sub-element addresses some of the issues addressed in the above noted planning documents. The body of community conditions and goals, policies and action statements are found in these sub-elements collectively.

SUMMARY OF ACCOMPLISHMENTS SINCE 1984

The Seismic Safety and Safety Sub-element was first written in 1984. Since that time there has been significant progress made in many of the areas addressed in that document. In these last 9 years there have been few areas of City planning or action that have received more attention than issues related to safety and seismic safety.

Several accomplishments that have been achieved since 1984 are in the areas of community development and building construction. To improve the seismic safety of buildings in the less stable soil areas of the city geotechnical reports are now required for developments north of Highway 237. A required minimum foundation pad height for developments in flood prone areas has also been established. Unreinforced masonry (URM) buildings pose a serious seismic hazard in every community. To address this issue in Sunnyvale a project to identify and perform hazard mitigation on these URM buildings was completed in 1990. Seismic safety of city buildings has also received considerable attention. A new Public Safety building completed in 1985 was constructed to seismic tolerances 50% higher than code standards. Seismic retrofitting of the Community Center, City Hall Annex, Library and Corporation Yard (stores section) were also completed. The seismic retrofitting of all 6 fire stations is scheduled to be completed in 1993 - 2 have been completed as of August, 1993. To accomplish the goal of reducing deaths, injuries and property damage from fires the city passed a residential sprinkler ordinance, fire resistive roof ordinance and smoke detector ordinance.

The storage and use of toxic gasses and the aboveground and underground storage of other hazardous materials was a major issue that has been addressed over the last 10 years. As a result of the efforts in these areas, in which City of Sunnyvale employees played a significant role, important state, county and local safety regulations regulating hazardous materials are on the books and being enforced. The implementation of these regulations and the creation of the Public Safety Department's Hazardous Materials Response Team are two of the major reasons the city has experienced a significant reduction in the number of hazardous materials spill incidents over the last 5 years.

Sunnyvale also has identified needed improvements to its infrastructure and has taken steps to complete the improvements. The city has completed the installation of a new domestic/emergency water transmission line in the southwestern part of town and another one is planned for the southeastern section of the city. This new line will complete the water delivery system grid to interconnect Sunnyvale's 3 water supply sources. The Public Works Department has identified 2 roadway overcrossings in need of seismic improvements. The improvements are scheduled to be completed in 1994. Public Works employees are also in the process of studying what improvements need to be made to an identified weak section in a levee at the Water Pollution Control Plant. Over the last 10 years the Santa Clara Valley Water District (SCVWD) has made a significant number of improvements to the creeks and channels in Sunnyvale. The SCVWD plans for further improvements in the next few years to ensure the ability of these creeks to contain the runoff from a 100 year flood.

Recognition of the need to implement the goals and policies and accomplish the actions stated in the 1984 Sub-Element could not have been accomplished without additional resources. The Public Safety Department was directed to implement many of the emergency preparedness goals and, in 1987, was authorized to hire additional staff for the Emergency Preparedness Unit. Staff increased from 2 to 7 full time employees to do emergency preparedness planning and training. This effort has allowed the city to expand into many new areas such as SNAP, SEPO and SARES. SNAP, Sunnyvale Neighborhoods Actively Prepare, is a self-help neighborhood emergency preparedness volunteer group coordinated by Public Safety employees. SEPO, Sunnyvale Emergency Preparedness Organization, is a organization similar to SNAP in the business community. SARES, Sunnyvale Amateur Radio Emergency Services, is a volunteer amateur radio network of over 150 people that assists the Public Safety Department at special events and in emergencies. The Public Works Department also has made significant improvements to its training program for the Water Pollution Control Plant Operators. Public Safety Department emergency preparedness staff also were involved in the reorganization of the city's Emergency Management Organization after the 1989 Loma Prieta earthquake. Another emergency preparedness project completed in 1993 was the revision of the city's Emergency Plan. The plan was rewritten to reflect the city's revised Emergency Management Organization.

The accomplishments noted here is only a summary of the significant changes that have occurred since the writing of the 1984 Seismic Safety and Safety Sub-Element. Details of these and other accomplishments are given throughout the text of this document.

SUMMARY OF COMMUNITY CONDITIONS

The following summary is derived from the information presented in the Community Conditions section of this sub-element. These findings form the basis of the goals and policies that follow.

Seismic Hazards

Damaging earthquakes are infrequent, however, they pose the most significant threat in relation to the destruction they may cause to the city.

Sunnyvale is located between two active earthquake fault zones. Scientists have identified four fault segments on which they believe large earthquakes are most likely to occur. There is a 67% chance for at least one earthquake of magnitude 7 or larger in the San Francisco Bay Area before the year 2020. An earthquake of this size could strike at any time. There could be more than 1 earthquake of magnitude 7 or larger in this period of time.

There is some evidence to infer the existence of inactive faults within the Sunnyvale planning area. Their presence has not be proved or disproved.

A local major earthquake could cause the failure of parts of the levee system and such a failure could lead to flooding in the northern parts of the city that are below sea level.

Fire in the aftermath of an earthquake could pose serious problems in Sunnyvale. Major variables that could intensify the situation include water system damage, multiple fires and isolation of some areas due to roadway overcrossing failures.

Flood Hazards

There are 5 sources of flooding that can threaten Sunnyvale:

Excessive precipitation - surface runoff
Tidal
Dam failure
Tsunamis
Combination of the above hazards

The Santa Clara Valley Water District maintains the channels of Calabazas Creek, Stevens Creek, East, West and El Camino flood control channels. These channels coupled with the city's storm drains take the majority of surface run-off to the bay. Tidal flooding could occur if the system of dikes and levees failed or their banks overflowed.

Severe Weather Hazards

Severe winter storms accompanied by high winds have caused considerable damage in the past. Damage has usually been limited to private property. Power loss due to high winds and winter storms can affect a significant portion of the city if the storms last for more than a few hours. Pacific Gas and Electric Company has the responsibility for utilities within the city limits. Electric power is supplied by high voltage lines originating outside the city. PG&E responds to service calls on a priority basis and has limited staff available to answer community needs.

Fire Hazards

Sunnyvale has a relatively low risk factor for fire loss and past fire experience has demonstrated Sunnyvale to be a relatively fire safe community. However, as in any city, the potential for serious fire events is ever present. A trained and well-equipped fire service must be ready to respond to fires and other incidents. While the potential for extraordinary disaster always exists, and while the aging process of the City and its buildings will have some adverse impact on fire loss, the overall environment is comparatively fire safe.

Hazardous Materials

Since 1950 Sunnyvale's growth has been closely tied with the evolution of the electronics industry. Large amounts of toxic and hazardous materials are now transported, stored and used in the city. The use and storage of hazardous materials is controlled through the Department of Public Safety.

All high and 75% of all moderate hazardous materials uses are located north of the Southern Pacific Railroad. This area is also the location of younger less stable soils which present significant ground failure and liquefaction potentials.

The primary risks to the community are soil contamination from underground storage tanks and spills/releases of hazardous materials in an accident or during a major seismic event. Regulations and controls of hazardous materials and wastes have been developed over the last 10-15 years.

Aviation Hazards

Sunnyvale lies in the landing pattern of Moffett Field and, during south winds, planes take off over heavily developed areas. Risk of future accidents exists even though the Navy's usage of Moffett Field as a Naval Air Station ends in 1994. Other than the potential for aircraft accidents, noise is the most significant concern of residents. Allowable land uses around Moffett Field are determined by accident potential and noise level.

Community Inventory

The local community, in relation to hazards and risk, can be broken into 5 key categories:

- Current Land Use
- Higher Risk Structures
- Non-Structural Elements of Buildings
- Critical Facilities
- Lifelines

Land development and use, from zoning for specific types of uses, to standards used to build structures, to the manner in which the community is maintained plays a major role in the overall assessment of risk. No community is free from all risks but land use choices can be made that mitigate risks to citizens while at the same time provide for the economic and social needs of the community. Structures may be considered in the **higher risk** category because of the type of occupancy. Apartment complexes, schools, major employment centers, shopping centers and other places of assembly are examples. Structures may also be in this category because of the age or type of construction. Examples include buildings constructed prior to the adoption of modern earthquake building standards and unreinforced masonry buildings. The contents of buildings (the **non-structural elements**) can cause injuries and damage and must be properly secured. Hospitals, police and fire stations are some of the **critical facilities** in a community. The functioning of these facilities is very important to a community's ability to respond to and recover from a disaster. A community's **lifelines** include essential services such as water, sewer, gas, electricity, telephones, streets and highways.

Isolation After a Disaster

Neighborhood and/or community isolation after a disaster such as a major earthquake is likely as some normal transportation routes and communication lines will be damaged during such an event. Internal isolation occurs when the City's ability to receive reports of emergencies, relay emergency information and respond to citizen's requests for help is limited by destroyed or damaged lifelines. External isolation occurs when the City's ability to communicate emergency conditions and the ability to request or receive outside emergency resources is lost due to destroyed or damaged lifelines.

Emergency Planning and Coordination

Responsibility for emergency preparedness and response lies both with the city and the citizens in the community. No government agency has all the resources needed to respond to all the needs of its citizens in or after a disaster. The city has established an emergency preparedness program which is housed in the Department of Public Safety. The program's goals include helping neighborhoods, schools and businesses to plan and prepare for disasters.

The city has established an Emergency Management Organization (EMO) to provide for the effective delivery of services in an emergency or disaster. The City does not have the resources to effectively respond to all emergencies during a disaster. During disasters, such as a major earthquake, the City will only be able to respond to a limited number of urgent calls for service. When city resources are exhausted outside assistance can be requested through an established network of local, regional and state mutual aid.

All city employees are disaster service workers. Many city employees are pre-assigned emergency tasks and others will be deployed where needed in case of an emergency. City employees are trained in emergency preparedness activities and their responsibilities as city employees during a disaster.

Community Resources

A preparedness program, called Sunnyvale Neighborhoods Actively Prepare (SNAP) has been implemented to encourage self sufficiency at the neighborhood level.

In cooperation with the American Red Cross and local school districts the city has established a disaster shelter program called Project ARK. The program involves stocking large containers with emergency supplies for up to 300 people for 3 days. Currently, there are 12 ARKS at 8 school sites throughout the city.

Amateur radio operators in the community have organized as an active emergency response group called Sunnyvale Amateur Radio Services (SARES). The group provides assistance to the Public Safety Department at both routine special events when additional radio communications are needed and during emergencies/disasters. SARES will play a major role in providing amateur radio communications during an emergency or disaster. In preparation for such an event emergency radio equipment and antennas have been installed at pre-designated locations throughout the city.

Sunnyvale Emergency Preparedness Organization (SEPO) provides business and industry representatives an opportunity to develop contacts and share emergency preparedness resources and information.

Post Disaster Recovery

The recovery from a disaster needs to be at least as well planned as the initial emergency response. Sunnyvale is taking a very proactive approach to this type of planning. Significant work has been done to develop standard operating procedures for disaster assistance centers, damage assessment, and financial recovery.

Community Condition Indicators

A list of this sub-element's indicators is provided on page 69.

SUMMARY OF GOALS AND POLICIES

GOAL A: ENSURE THAT NATURAL AND HUMAN-CAUSED HAZARDS ARE RECOGNIZED AND CONSIDERED IN DECISIONS AFFECTING THE COMMUNITY, AND THAT LAND USES REFLECT ACCEPTABLE LEVELS OF RISK BASED ON IDENTIFIED HAZARDS AND OCCUPANCY.

Policy A1 Land Use

Evaluate and consider existing and potential hazards in developing land use policies. Make land use decisions based on an awareness of the hazards and potential hazards for the specific parcel of land.

Policy A2 Flood Hazards

Take measures to protect life and property from the effects of a 1% (100 year) flood.

Policy A3 Hazardous Materials

Promote a living and working environment safe from exposure to hazardous materials.

Policy A4 Aviation Hazards

Make planning decisions that establish and/or maintain a safe mix of aviation and land use for the areas affected by Moffett Field.

Policy A5 Essential Services

Maintain lifelines* in good operating condition to lessen damage and increase survivability after a major disaster.

* Lifelines are essential services necessary for the continued normal functioning of the community, e.g. water, gas, electricity, transportation and communication lines.

GOAL B: ENSURE THAT THE CITY, ITS CITIZENS, BUSINESS AND INDUSTRY ARE PREPARED TO EFFECTIVELY RESPOND TO MAJOR EMERGENCIES.

Policy B1 Emergency Response Facilities
Maintain and construct city facilities utilized for emergency response so that they remain operable after a major seismic event.

Policy B2 Emergency Management Organization
Provide for the emergency management of the city in order to protect life and property in the event of a disaster.

Policy B3 Emergency Planning & Coordination
Provide an integrated approach to planning and preparedness for emergencies and disasters.

Policy B4 Schools
Provide information and assistance to public/private schools and day care centers to plan and prepare for emergencies and disasters.

Policy B5 Business and Industry
Provide information and assistance to business and industry to plan and prepare for emergencies and disasters.

Policy B6 Community
Provide the citizens of Sunnyvale information, encouragement and assistance with emergency planning and preparedness.

Policy B7 Communications
Provide emergency radio communications for coordination of emergency response and the capability to communicate with outside agencies and citizens.

GOAL C: ENSURE THAT THE CITY, ITS CITIZENS, BUSINESS AND INDUSTRY ARE PREPARED TO RECOVER FROM DISASTERS.

Policy C1 City Government
Provide for the continuation of city government and services following a major disaster.

Policy C2 Citizens and Business/Industry
Encourage citizens and business/industry to plan for recovery from disasters.

COMMUNITY CONDITIONS

GEOLOGIC SETTING

Sunnyvale lies at the southern end of San Francisco Bay and is built atop the alluvial deposits (different mixtures of silt, clay and sand) that surround the margins of the bay. The areas closest to the bay are overlain by unconsolidated fine silty clay, known as "bay mud", which varies in thickness from a few feet to as much as 30 feet. Generally, the older more stable alluvium is south of the railroad tracks and the younger less stable material is to the north. Bedrock generally lies beneath the area at depths of 300' or more. Figure 1, page 15, summarizes the alluvium depositional process that exists today. During periods of heavy rain the easily eroded rock and soils of the uplands cause streams to carry heavy loads of sediment. When streams overflow their banks they spread sediment-laden waters over the low plains and basins. Normally, the finer sediment will be carried by the stream all the way to the bay and deposited as fine estuarine mud. This depositional process, coupled with an active tectonic (land movement) setting, is an important geologic process that must be considered in land use planning and structural design.

Sunnyvale's soil is largely composed of expansive clays. Expansive clays are a poor foundation material because they swell when wet and shrink when dry, producing extensive cracks. The effects of these clays have been partially mitigated by soils engineering studies required by the Subdivision Map Act. The City requires soils reports as part of the permitting process to determine if the proper calculations for design of foundation and structural components have been met. The soils reports are not used to determine the seismic stability of the subsurface elements. In the area north of Highway 237 a geotechnical report may be required for some developments to determine specific building structural needs for a particular development site.

Sunnyvale's topography is essentially flat, dropping from an elevation of 300 feet to sea level. The slope across the city is in a northeasterly direction from the high point in the southwest corner to the bay. The average slope is

Existing Depositional And Erosional Process

FIGURE 1

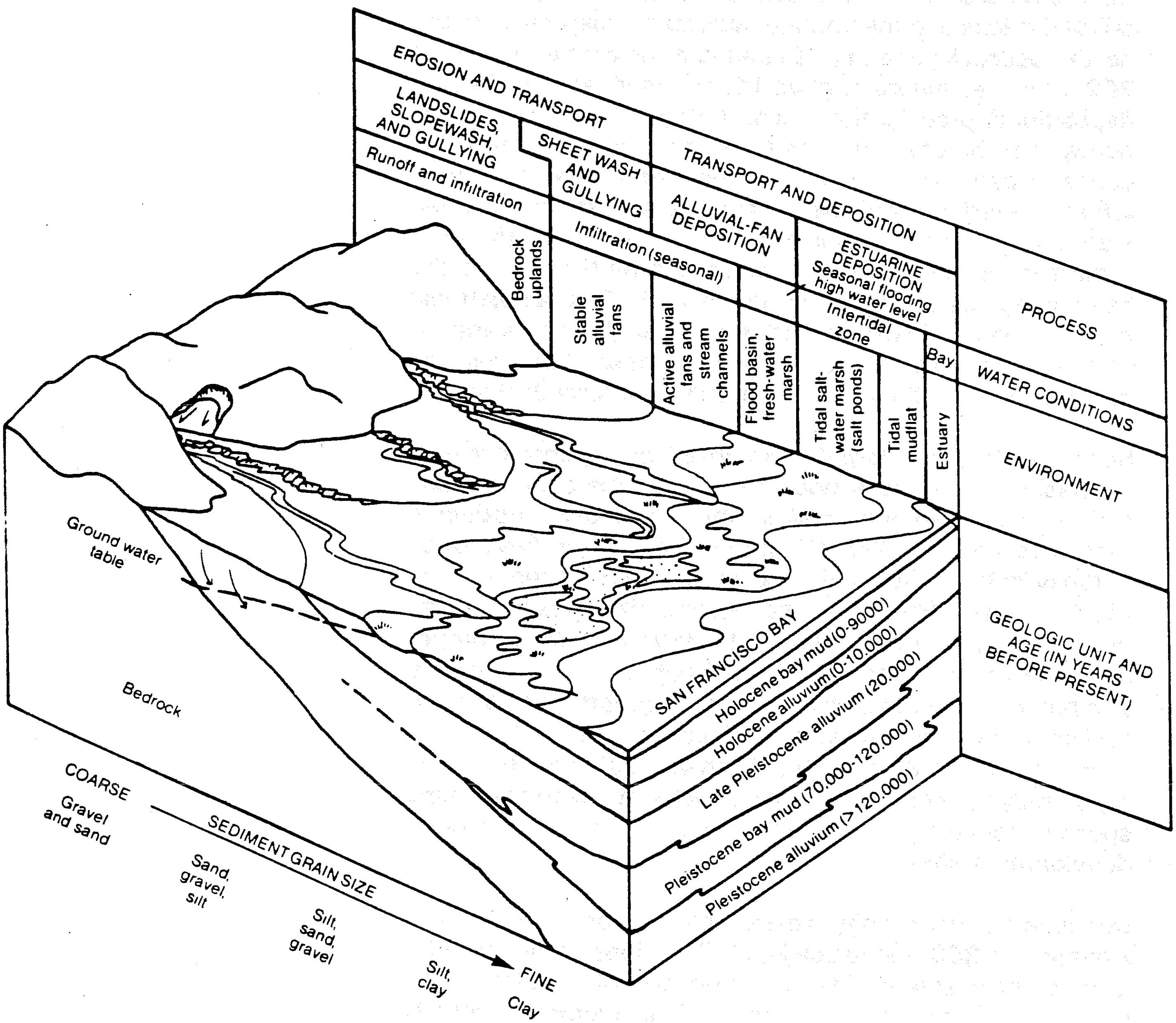


Diagram of modern depositional and erosional processes along the bay plains. U.S.G.S. 1979.

approximately 0.9% and that slope is fairly consistent from Homestead Road to the bay. The city is bordered on the east by Calabazas Creek and on the west by Stevens Creek. These streams, assisted by two flood control channels (Sunnyvale East, West and El Camino flood control channels), play a major role in the control of surface run-off during rain storms. They are described in more detail in the Flood Hazard section of this sub-element and the Surface Runoff Sub-Element.

SEISMIC HAZARDS

An earthquake is a catalyst that may bring about a complex chain of natural events that are often disastrous. It is difficult to predict exactly how the various subsurface and surface geologic materials will react. The major geologic effects of earthquakes include surface faulting (ground rupture), ground shaking, ground failure, and flooding from tsunamis (seismic sea waves) and seiches (earthquake generated standing waves). These hazards may act as constraints on development. For instance, buildings constructed in areas subject to severe ground shaking need to be engineered to withstand that effect. The following is a discussion of individual seismic hazards:

Earthquake Faults

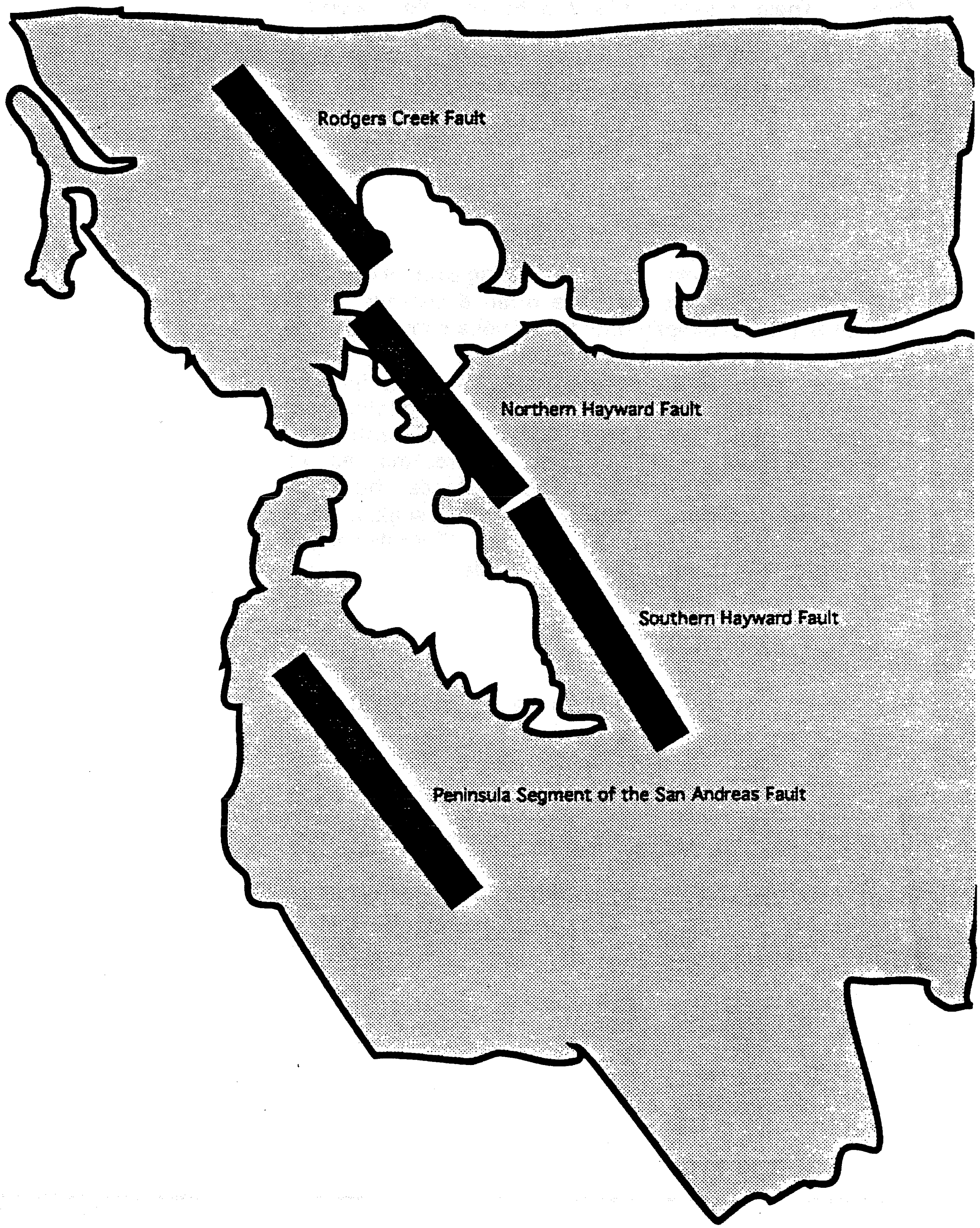
The characteristics of earthquake faults are important in planning and preparing for the future. The way a fault moves, the magnitude and intensity in a given event, how often it may move and how far it moves are essential pieces of information needed to determine an earthquake's potential effect on the city's population and infrastructure.

Faults are fractures in the earth's surface along which opposite sides have moved relative to one another in response to an accumulation of stress. The Bay Area is

Major Fault Lines

FIGURE 2

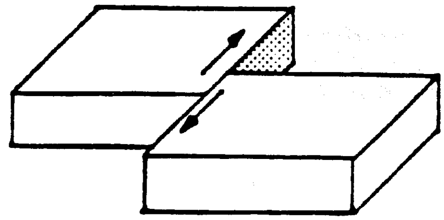
This map illustrates the major fault segments in the Bay Area along which experts believe large earthquakes are most likely.



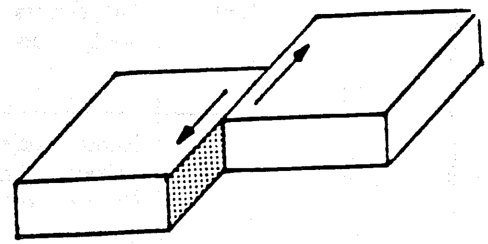
crisscrossed by numerous faults that are generally associated with the San Andreas Fault System. Figure 2, page 17, shows their approximate locations. The San Andreas fault system is a network of faults that is responsible for most of the movement between the North American and Pacific plates.

Seven miles south of the Civic Center lies the San Andreas fault zone. Ten miles northeast are the Hayward fault zones.These are considered to be active fault zones. Active faults are defined by the state as those that have moved within the last several thousand years. Most of the faults have a "right-lateral strike slip" type of movement as illustrated in Figure 3. The area is splintered with lesser known but potentially active faults, which generally run parallel to the Peninsula Segment of the San Andreas fault. Among these splinter faults, in the Cupertino planning area, are the Sargent-Berrocal and the Monte Vista faults. These faults have a "dip-slip" type of movement also shown in Figure 3.

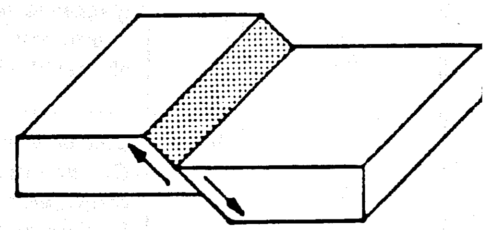
Over the last 25 years scientists have conducted various studies in California to determine if they can locate undiscovered earthquake faults. One of these studies was done in the Sunnyvale area. A 1981 report published by the United States Geological Survey (USGS) lists 3 "inferred" (or suspected) faults in Sunnyvale. Their listing was based on aeromagnetic anomalies which were detected by instruments in an area fly over during the mid 1970's. These "faults" were named the San Jose, Santa Clara and Cascade faults. The San Jose inferred fault is the shape of a slight curve and roughly runs from the intersection of Highways 101/237 through the intersection of Sunnyvale Avenue/Evelyn to the intersection of Lawrence Expressway/Reed Avenue. The Santa Clara inferred fault runs in a slight curve near the intersection of Bernardo/Knickerbocker to the intersection of Lawrence Expressway/Homestead. The Cascade inferred fault is much smaller and runs in a small curve near The Dalles/Stevens Creek to Wright/Pocatello. The use of aeromagnetic anomalies to infer the existence of faults is a



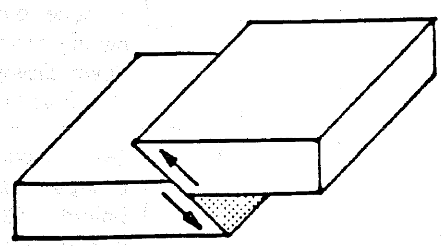
Right-lateral strike slip



Left-lateral strike slip



Dip-slip (normal)



Dip-slip (reverse or thrust)

FIGURE 3

FIGURE 4

RICHTER MAGNITUDE SCALE	MODIFIED MERCALLI INTENSITY SCALE [from Richter, 1958]	
	I.	Not felt. Marginal and long period effects of large earthquakes.
2.0	II.	Felt by persons at rest, on upper floors, or favorably placed.
	III.	Felt indoors. Hanging objects swing. Vibration like passing of light trucks. Duration estimated. May not be recognized as an earthquake.
3.0		
	IV.	Hanging objects swing. Vibration like passing of heavy trucks; or sensation of a jolt like heavy ball striking the walls. Standing motor cars rock. Windows, dishes, doors rattle. Glasses clink. Crockery clashes. In the upper range of IV wooden walls and frame creak.
4.0		
	V.	Felt indoors; direction estimated. Sleepers wakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Doors swing, close, open. Shutters, pictures move. Pendulum clocks stop, start, change rate.
5.0	VI.	Felt by all. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware broken. Knickknacks, books, etc., off shelves. Pictures off walls. Furniture moved or overturned. Weak plaster and masonry D cracked. Small bells ring (church, School). Trees, bushes shaken (Visibly, or heard to rustle).
	VII.	Difficult to stand. Noticed by drivers of motor cars. Hanging objects quiver. Furniture broken. Damage to masonry D, including cracks. Weak chimneys broken at roof line. Fall of plaster, loose bricks, stones, tiles, cornices (also embraced parapets and architectural ornaments). Some cracks in masonry C. Waves on ponds; water turbid with mud. Small slides and caving in along sand of gravel banks. Large bells ring. Concrete irrigation ditches damaged.
6.0	VIII.	Steering of motor cars affected. Damage to masonry C; partial collapse. Some damage to masonry B; none to masonry A. Fall of stucco and some masonry walls. Twisting, fall of chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes.
	IX.	General panic. Masonry D destroyed; masonry C heavily damaged, sometimes with complete collapse; masonry B seriously damaged. (General damage to foundations.) Frame structures, if not bolted, shifted off foundations Frames racked. Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground. In alluviated areas sand and mud ejected, earthquake fountains, sand craters.
7.0	X.	Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, embankments. Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly.
	XI.	Rails bent greatly. Underground pipelines complete out of service.
8.0	XII.	Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown into the air.

controversial method that does not have widespread support among geologists. There is not enough scientific evidence, as yet, to conclusively prove or disprove their existence or exact location if they do exist.

Earthquake Magnitude and Intensity

The severity of an earthquake is normally expressed in two ways - magnitude and intensity. The Richter scale expresses magnitude - the amount of energy released by an earthquake. The Modified Mercalli Scale and the San Francisco Scale are subjective measurements of earthquake intensity. They describe the effects on people, to structures and the earth's surface.

An earthquake of large magnitude does not necessarily cause the most intense surface effects. The effect in a given region depends to a large degree on local surface and subsurface geologic conditions. An area like Sunnyvale, underlain by unconsolidated alluvial materials, is likely to experience much more noticeable effects than an area equally distant from the earthquake epicenter but underlain by hard materials such as granite.

An earthquake's destructiveness to a particular area depends on many factors. These include the magnitude, intensity, focal depth, distance from the epicenter, local geologic conditions and the age/design of buildings and other works of man. The extent of damage also depends on the density of population in the affected area.

There are several different earthquake intensity scales that are commonly used by USGS professionals and the news media to describe the severity of earthquakes. The most common are the "Richter Scale" and "Modified Mercalli Scale". Figure 4, page 19, is a comparison of these two. Figure 5, page 22, is another scale called the "1906 Intensity Scale for San Francisco". All 3 are scales used describe an earthquake's magnitude and intensity.

Ground Shaking and the 1989 Loma Prieta Earthquake

Ground shaking is the most widespread effect of an earthquake. The location of the epicenter and the magnitude will determine the extent of damage from one area to another. The sudden release of energy in an earthquake causes waves to travel through the earth. These waves not only shake structures, but can trigger secondary effects such as landslides or other types of ground failure. Shaking generally increases in severity with the increase of an earthquake's magnitude. It is also dependent upon a number of variables such as the distance from the fault and the local geologic and soil conditions. Waves radiating from the earthquake's epicenter may cause the ground to shake more severely in less stable soils such as bay mud. Studies of many earthquakes indicate that property damage from ground shaking is generally greatest in areas of unconsolidated and water saturated soils.

Damage from ground shaking can be lessened prior to development by requiring seismic and geologic site investigations before approving development proposals and enforcing building design and construction standards. Buildings constructed on adequately prepared foundations and built conforming to modern building codes (1973 and after) provide the best insurance against the damage caused by the violent shaking in a major earthquake. Potential damage can also be mitigated when existing older buildings (built to comply with less stringent seismic standards) are remodeled by requiring the owners to improve the building's seismic stability as part of the remodeling process. Presently, the city requires a soils report for all new developments or redevelopments and strict compliance with all building codes. Geologic site investigations and reports are required for some developments north of Highway 237 where the risk of potential earthquake damage is increased due to the areas type of soil. The geotechnical report is a detailed assessment of the soil upon which the building will be constructed and specific building design requirements that will help mitigate the effects of an earthquake in this area.

FIGURE 5

1906 INTENSITY SCALE FOR SAN FRANCISCO *The following grades of apparent intensity were used by Wood (1908, pp.224-225) in the City of San Francisco after the California earthquake of April 18, 1906.*	
Grade A:	**Very violent.** Comprises the rending and shearing of rock masses, earth, turf, and all structures along the line of faulting, the fall of rock from mountain sides; numerous landslips of great magnitude, consistent, deep and extended fissuring in natural earth; some structures totally destroyed.
Grade B:	**Violent.** Comprises fairly general collapse of brick and frame buildings when not unusually strong, serious cracking of brickwork and masonry in excellent structures; the formation of fissures, step faults, sharp compression anticlines, and broad, wavelike folds in paved and asphalt-coated streets, accompanied by the ragged fissuring of asphalt; the destruction of foundation walls and underpinning structures by the undulation of the ground; the breaking of sewers and water mains; the lateral displacement of streets and the compression, distension and lateral waving or displacement of well-ballasted streetcar tracks.
Grade C:	**Very strong.** Comprises brickwork and masonry badly cracked, with occasional collapse; some brick and masonry gables thrown down; frame buildings lurched or listed on fair or weak underpinning structures with occasional falling from underpinning or collapse, general destruction of chimneys and of masonry, brick or cement veneers; considerable or crushing of foundation walls.
Grade D:	**Strong.** Comprises general but not universal fall of chimneys; cracks in masonry and brickwork, cracks in foundation walls, retaining walls, and curbing; a few isolated cases of lurching or listing of frame buildings built upon weak underpinning structures.
Grade E:	**Weak.** Comprises occasional fall of chimneys and damage to plaster; partitions, plumbing, and the like.

FIGURE 6

PROBABILITY OF FUTURE EARTHQUAKES

FAULT SEGMENT	PREVIOUS EVENT	EXPECTED MAGNITUDE	PROBABILITY 1990-2020
Loma Prieta Segment San Andreas Fault	1989	7	Very Low (<1%)
Peninsula Segment San Andreas Fault	1906	7	23%
Healdsburg-Rodgers Creek Fault	1808 (or Earlier)	7	22%
Southern Segment Hayward Fault	1868	7	23%
Northern Segment Hayward Fault	1836	7	28%
Combined Northern-Southern Segments Hayward Fault	None Known	7.5	Less Likely, But Plausible

Our most recent significant earthquake was the 7.1 Loma Prieta Quake which occurred on October 17, 1989. Loma Prieta was not the "big one", but rather a moderately big earthquake. It certainly was destructive to some parts of the Bay Area, but nowhere near the magnitude or intensity of the great San Francisco earthquake of 1906. The inevitability of an earthquake causing widespread damage throughout the Bay Area still is a very real probability that confronts everybody living in this area. A new study released in July 1990 by the United States Geological Survey, states there is a 67 percent chance of another earthquake the size of Loma Prieta sometime during the next 30 years. The report also says that the next one will most likely strike farther north than Loma Prieta (epicenter in the Santa Cruz Mountains 7 miles NE of Santa Cruz), somewhere between San Jose and Santa Rosa on either side of the Bay. During the Loma Prieta earthquake, shaking was so severe in the Santa Cruz Mountains that a van overturned, treetops snapped off, and many people were thrown to the ground. If the epicenter of the next earthquake strikes closer to an urban area it will cause significantly greater damage.

Sunnyvale sustained relatively minor damage from this earthquake. Of the 110 city and commercial buildings inspected only 2 facilities suffered major structural damage. The Westinghouse facility on Hendy Avenue was forced to demolish a water tower on their property and the Arboretum building at the Sunnyvale Community Center required renovation. The City received $164,633 from the state for reimbursement of expenses due to the earthquake.

After the Loma Prieta earthquake, a panel of experts convened to determine the probabilities of future large earthquakes in the San Francisco Bay Area. Their report, issued in July 1990, endorsed by both the National and the California Earthquake Prediction Evaluation Councils, identified four fault segments in the Bay Area which they now believe large earthquakes are most likely to occur.

Those areas are:

- the Peninsula Segment of the San Andreas fault between Los Gatos and Hillsborough
- the Southern Hayward fault (between Fremont and San Leandro)
- the Northern Hayward fault (between San Leandro and San Pablo Bay)
- the Rogers Creek fault between San Pablo and Santa Rosa.

They estimated a probability of about 25 percent for a large earthquake on each of these fault segments within 30 years. When the probabilities of earthquakes on all of these segments are combined mathematically, there is a 67 percent chance for at least one earthquake of magnitude 7 or larger in the San Francisco Bay Area between 1990 and 2020. Such an earthquake could strike any time. Figure 6, page 22, is a chart listing the probability of future earthquakes in the Bay Area.

The Panel also concluded that:

1) There could be more than one earthquake of magnitude 7 or larger in this 30 year period.

2) Major earthquakes on all four fault segments are likely within the next 100 to 150 years.

3) Each earthquake is likely to be of magnitude 7. If two fault segments slip during the same earthquake, for example along the Hayward fault, then the anticipated magnitude could be as large as 7.5.

4) A repeat of the magnitude 8.3 San Francisco earthquake of 1906, which broke several segments of the San Andreas fault from south of San Jose to Cape Mendocino (a distance of more than 270 miles), is not considered likely during the next few decades.

5) Numerous earthquakes with magnitude of about 6 are also likely; these smaller earthquakes could cause some damage, especially near their epicenters.

Ground Failure

Most ground failure from earthquake shaking results in displacement in the surface due to loss of strength of underlying materials. The various types of ground failures include landslide, liquefaction, lateral spreading, lurching and differential settlement. These effects usually occur in soft, fine-grained, water-saturated alluvium generally found in areas near San Francisco Bay and areas built on landfill.

The liquefaction process involves the transformation of loose water-saturated silt or sandy soil into a fluid condition resulting in ground failure. The ground fails when the liquefied material is not confined and flows out toward a free face such as creek beds. Conditions for potential liquefaction exist throughout the city but the potential is generally greatest north of Highway 101. The liquefaction potential increases during the rainy season when the water table rises closer to the surface.

Lateral spreading is movement, or "spreading out", of land that occurs most commonly on gentle to nearly horizontal slopes composed of moist, sandy soil underlain by loose to moderately dense granular deposits or layers. Cracks, fissures and differential settlement usually accompany this effect, which has proved to be very damaging to structures and utilities. In 1906, the effects of liquefaction, lateral spreading, differential settlement and subsidence were observed locally, especially along what is today Highway 237.

Seismically Induced Flooding

Earthquakes may generate flooding from a tsunami (sea wave or "tidal wave" caused by an earthquake), seiche (wave generated in an enclosed body of water such as a lake or swimming pool) or dam failure. Coastal regions bordering oceans are the most susceptible to tsunamis. A tsunami off the San Francisco coast could cause bay water to top local levees, especially if it arrived at high tide. If at the same time bay water elevation and/or large runoff from local storms was increased by northerly wind waves, the chance for topping would be increased.

A local major earthquake could cause the failure of parts of the levee system and such a failure could lead to the flooding of those areas presently below sea level. Salt water flooding that would follow dike failure is estimated at (using the worst possible combination of circumstances) approximately 10 feet above mean sea level. The flooding could be increased by fresh water flooding from an excessive amount of surface/storm drain runoff or by levee failure along Calabazas Creek and/or the flood control channels in the unlikely event of an earthquake occurring during a winter storm. If all of the postulated events occur we can expect severe flooding in many areas of the city. Dikes and flooding are discussed in more detail in the Flood Hazards section.

Seismic seiches are earthquake generated waves within enclosed or restricted bodies of water - like sloshing water out of a glass. The risk of seismic seiches in the southern reaches of San Francisco Bay is not known. Water sloshing within structures such as elevated tanks or ground level storage tanks could cause collapse or severe distortion of the container.

Failure of the Stevens Creek Reservoir dam caused by an earthquake could also affect the city. The area most significantly affected would be the southwest part of the city outh of Remington and west of Sunnyvale-Saratoga Road. This estimated flood inundation area is based upon the maximum 3,700 acre-feet storage capacity of the reservoir. Depending upon the quantity of water released the depth of flooding could vary between several inches to several feet. For any large release of water Highway 280 would act as a barrier to keep some water out of Sunnyvale.

Safety improvements to the reservoir and the dam were made in 1985. It was engineered to withstand an earthquake on the San Andreas Fault of an 8.25 magnitude on the Richter Scale. Upstream and downstream berms were built and the dam was raised ten feet. The contour of the gentle slopes surrounding the dam, plus the compacted earth along the sides and the face of the dam, were designed to encourage run-off and the collection of water and to discourage landslides. A hydro gauge was installed to alert the Santa Clara Valley Water District of any sudden, unplanned release of water. The spillway was also upgraded to be capable of withstanding a flow of 15,600 cubic feet per second. For comparison, if the spillway was not there and it was just a river bed passageway for water, it would only allow a flow of 6,000 cubic feet per second. Safety inspections are done after all earthquakes of 5.0 or greater magnitude.

No landslides on any of the county's dams have occurred in the past decade, even in the 1983 and 1986 storms or after the 1989 earthquake.

Seismic Hazard Areas

Maps predicting the severity of earthquake ground shaking usually depict intensity. Three factors affect the intensity experienced at a location:

- the size of the earthquake, or magnitude
- the distance to the earthquake fault; and
- the geologic materials underlying the site.

Larger magnitude earthquakes generally cause the ground to shake harder and longer, and they affect larger areas. This relationship is generally well understood. On the other hand, many commonly believe that most damage will occur at the epicenter of the earthquake. (The epicenter is the point on the surface above the location where the fault begins to slip.) However, the earthquake epicenter is **NOT** the point at which most damage occurs. The fault slippage can be tens of miles long and waves are generated along the entire length of the fault that ruptures. Thus, predictions of ground shaking intensity are based not on distances from hypothetical epicenters, but on distances from known faults.

The final factor affecting intensity at a site is the geologic material underneath that site. Thick, loose soils tend to amplify and prolong the shaking. The worst such soils in the Bay Area are the loose clays bordering the bay, commonly referred to as "bay mud". The rock that is least susceptible to shaking is granite. The remaining materials fall between these two extremes, with the thicker soils in the valleys being more susceptible to shaking and the rocks in the hills being less susceptible.

Earthquake Related Fire

Fire in the aftermath of an earthquake has the potential of causing greater loss of life and property damage than the earthquake itself. As a result of the 1906 earthquake, at least 80% of all property loss in San Francisco was attributed to fire. The spread of the fire was due to an inadequate water supply and the predominately wood building construction. Today, even though buildings are built to stricter fire codes, fires resulting from an earthquake still pose a serious danger to every community. Severed gas mains and electrical lines are common ways these fires start. Major fires in San Francisco after the Loma Prieta Earthquake on October 17, 1989 are recent examples. In Sunnyvale the most serious problems will center in areas that are older and have structures of questionable earthquake resistance (e.g. unreinforced masonry and older commercial "tilt-up" construction).

Sunnyvale should also expect numerous other fires throughout the city following a major earthquake. A number of variables may tend to intensify the situation:

- the extent of damage to the water system
- the extent of isolation due to bridge and/or freeway overpass collapse
- the extent of roadway damage and/or amount of debris blocking the roadways
- time of year (e.g. seasonal hot, high winds)
- the large number of dwellings with wood shingle roof coverings could result in spreading fires from flying brands
- time of day will influence the amount of traffic on roadways and could intensify the risk to life during normal business hours
- the availability of timely mutual aid since most other surrounding jurisdictions would be experiencing their own problems

The other serious fire hazard (or exposure hazard) relates to the transportation, use and storage of hazardous materials. This topic is discussed separately in the hazardous materials section.

Seismic Hazard Summary

Since 1984 substantial change has occurred to the City's infrastructure, in the planning of response to seismic events and in the regulations which govern the construction, remodeling and use of private structures and their contents. These actions serve to mitigate the potential damage of a seismic event and enhance the City's capabilities to respond. These changes will be detailed in later sections.

FLOOD HAZARDS

Sunnyvale occupies an area of relatively young and active geological processes. Before cultural activities disrupted the soil depositional process, Sunnyvale's land area was interfaced between two flooding sources: the alluvial fan deposits of the intermittent streams from the mountains and, the periodic flooding from the bay. Historically, Sunnyvale has been subject to substantial floods, although these are not thought to be the greatest that can occur.

There are 5 sources of flooding that can threaten Sunnyvale:

Excessive precipitation - surface runoff
Tidal
Dam failure
Tsunamis
Combination of the above hazards

Dam failure and tsunamis were addressed in an earlier section entitled "Seismically Induced Flooding".

Excessive Precipitation and Surface Runoff

The areas in Sunnyvale that will flood as a result of heavy rains and the resulting surface runoff border Stevens Creek, Calabazas Creek and the East, West and El Camino flood control channels. Specific street flooding will also occur from clogged storm drains and low places in some roadways.

Six significant flooding events have been recorded in Sunnyvale. These occurred in 1955, 1958, 1963, 1968, 1983 and 1986. The storm of December 21 through December 24, 1955 was the most severe. A total of 53 houses in Sunnyvale were flooded. The majority of the houses flooded were located south of the Southern Pacific Railroad tracks and east of Lawrence Expressway. This area is no longer in Sunnyvale as it was annexed by the City of Santa Clara around 1960.

The major reason for flooding in the northern portion of the city in the mid 50's was the lack of an outlet for Calabazas Creek to the bay. Before 1955 local ranchers had filled in, leveled and planted the original creek bed north of Kifer Road and dug a small ditch to connect the north end of Calabazas Creek with San Tomas Creek. San Tomas Creek was not large enough to carry the flows from its own runoff areas during major storms - let alone handle the additional flows from the larger Calabazas Channel. The Calabazas Channel has since been reopened, widened and diked. Calabazas and Stevens Creeks are assisted in the control of surface runoff by three flood control channels (East, West and El Camino Channels) maintained by Santa Clara Valley Water District (SCVWD). The channels and the creeks empty into the bay along leveed sloughs. The stream channels are incised, but large areas on either side of them are vulnerable to flooding should the streams top their banks during a storm.

Sunnyvale's Storm Drain Master Plan was designed in 1958 and revised in 1967. The storm drain system has been designed to handle only the surface runoff within the city. It is addressed in detail by the Surface Runoff Sub-Element. Since 1958, Sunnyvale's storm drainage and flood control potential has significantly improved. The city has constructed an extensive storm drain system (approximately 150 miles) and continues to improve upon it. The low lying northern areas of the city are assisted by two pumping stations to pump storm drain runoff into the bay. Pump station number 1 is located north of Caribbean Drive. Storm water runoff from Moffett Industrial Park drains through low level channels and pipes into a small lagoon where it is pumped into the Guadalupe Slough. Pump station number 2 lifts the storm water runoff from the low lying area in northeast Sunnyvale and discharges it directly into Calabazas Creek.

Past experience has demonstrated some weakness in the flood control channels maintained by the SCVWD. Calabazas Creek between Homestead Road and Lawrence

Expressway has been unable to pass a 10-year storm run off, let alone a 100 year flood. During the extensive rain storms January, 1983 and February, 1986, Calabazas Creek overflowed its banks flooding the rear yards of homes backing up to the creek. The bridge at Lochinvar was topped sending storm waters and debris along Lochinvar from Vireo to Benton. The fast running waters eroded the channel causing isolated wash outs along the banks in the area south of Lochinvar. Channel erosion and silt deposits were problems along southern reaches of the East Channel between Inverness and Ashbourne. Along the West Channel, at Caribbean, heavy run off coupled with high tide caused topping of the dike. Also, the levees were weakened by burrowing animal tunnels which allowed water to penetrate and leak from the base. On numerous occasions during the heavy storms of January through March of 1983, the Calabazas Creek came within 1 foot of the top along the northern reaches. In 1986 the creek overflowed its banks at Homestead, Lochinvar, Highway 101 and at Highway 237, blocking the westbound lanes of traffic.

Standards set by the Federal Emergency Management Agency (FEMA) and the Army Corp of Engineers for flood plain management call for a minimum 3 foot "freeboard" (clearance) for a 1% flood incident. In the years following these storms the SCVWD has made many improvements to the flood control channels that have increased their capacity. The Santa Clara Valley Water District constructed Calabazas Creek to contain the runoff from a 100 year flood but increased storm drain runoff from the development of the surrounding land has not allowed the creek to achieve this goal. In April, 1992, the SCVWD issued a publication entitled "Calabazas Creek Planning Study". This report detailed the results of a comprehensive study of the creek. As a result of this study the SCVWD has planned additional improvements in the next few years to increase the capacity of Calabazas Creek. The plans include the building of flood walls that will raise the levee banks several feet between Arques Avenue and the bay. In southern Sunnyvale, additional channel openings, called "boxes", will be installed under Homestead, Vireo and Lochinvar expanding the creek size under these streets. Gabion Line Channel (heavy gauge wire netting) will be added to the creek banks between Lawrence Expressway and Pruneridge Avenue to increase its flow. The SCVWD is making these improvements to make Calabazas Creek capable of containing runoff from a 100 year flood.

Tidal Flooding

Without the present system of dikes and levees, a part of Sunnyvale normally would be subjected to flooding by tides. It is assumed that this would still be the case if these dikes were to be topped, breached or failed.

The dike system originally was designed to contain holding ponds that ultimately served as salt evaporators for commercial production rather than a barrier to prevent flooding a populated area. The dikes are constructed of weak, locally derived bay materials, that are constantly undergoing settlement, erosion by the elements and damage by burrowing animals. They have a high potential for liquefaction during a major earthquake.

The problem of dike vulnerability has been compounded by the general subsidence of the ground surface in this part of Santa Clara County - 6 to 8 feet from 1916 to 1966 in the northern areas of the city. During the same time frame the ground subsided 3 - 4 feet in the areas along El Camino Real. Until ground water recharge methods were initiated in the late 1960's the amount of freeboard on the dikes was constantly being diminished by an accelerated subsidence rate caused by groundwater withdrawal. Although human caused subsidence has been minimal since 1967 a certain amount of subsidence is happening naturally due to regional tectonic movements, peat decay and a 3 inch rise in the sea level during the last 50 years.

Flood Management

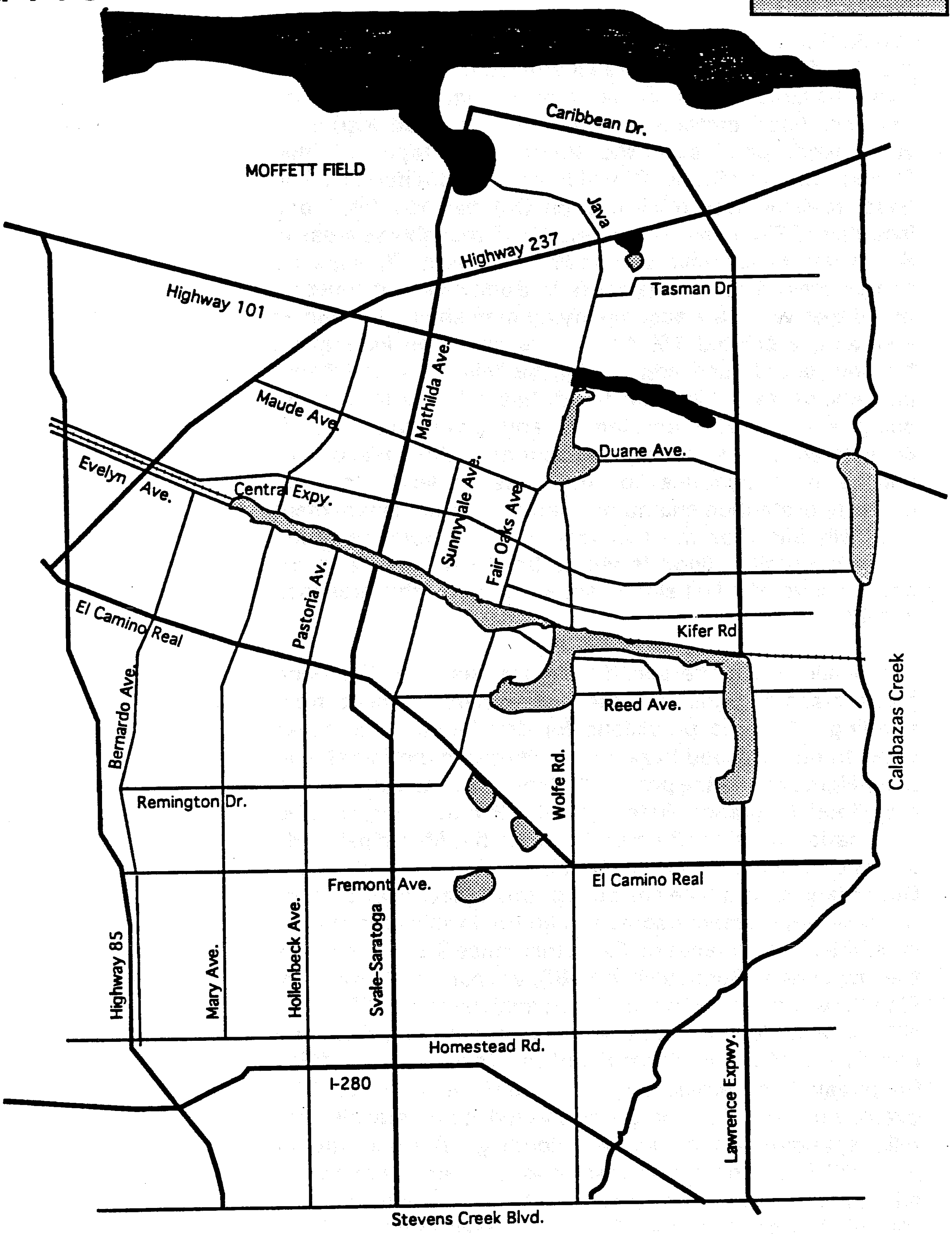
In 1975 and 1976 the Federal Emergency Management Agency (FEMA) investigated the existence and severity of flood hazards in Sunnyvale. Calabazas Creek, Stevens

Creek, Sunnyvale East, West and El Camino Channels and the San Francisco Bay were all studied in detail. Areas of flood hazards, flood-related erosion hazards, mudslide hazards, flood protection measures and flood insurance zones were identified in the report. Their report is titled "Flood Insurance Study, City of Sunnyvale, California". The latest revision was published on October 18, 1983 and included a "Flood Insurance Rate Map" that shows areas in Sunnyvale susceptible to flooding. Figure 7, page 35 shows these flood prone areas in Sunnyvale. It must be noted that while the accompanying map shows historic as well as a projected 1% flood, it is based on incomplete historic records and engineering modeling. A 1% flood, also known as a 100 year flood, has a 1% probability to being equaled or exceeded in any given year. It is considered to be a severe flood, but one with a reasonable chance of occurrence for purposes of land planning, property protection and human safety. Flood management is usually based on the 100 year flood. In Sunnyvale, the greatest possible flood is yet to be experienced and, as noted above, the last significant storm to hit this area was in 1986.

Sunnyvale has made specific requirements for the flood prone areas to minimize potential property damage from flooding. Specific provisions for developments in these areas to reduce flood hazards include minimum foundation pad heights above the projected flood depth as specified on the Flood Insurance Rate Map (F.I.R.M.). For detailed information refer to Chapter 16.62 of the Municipal Code and the F.I.R.M. on file in the Public Works Department. Due to land subsidence and construction that occurred prior to these requirements some structures in this area do not meet the current standard. Flood Insurance Studies, such as the one done in Sunnyvale in 1983, are part of the National Flood Insurance Program (NFIP) administered by FEM. The NFIP is a nationwide federal program resulting from the enactment of the National Flood Insurance Act of 1968. Sunnyvale has participated in the NFIP since 1970. The overall purpose of the program is to reduce federal disaster relief spending associated with flooding. Another goal of the NFIP is to encourage state and local governments to adopt sound flood plain management programs to mitigate identified flood hazards. The City has adopted the flood plain management regulations for these areas. Detailed

Flood Prone Areas

FIGURE 7



Areas of 100-year shallow flooding with depth from 1 to 3 feet.

Areas of 100-year flooding with depth over 3 feet.

UNSHADED- Areas of shallow flooding with depth less than 1 foot.

*Information obtained from FEMA's Flood Insurance Rate Map.

information on the NFIP and City adopted regulations can be obtained from the Public Works and Community Development Departments.

SEVERE WEATHER HAZARDS

The only recorded tornado ever to strike Sunnyvale was in 1951. It destroyed the Southern Pacific Railroad Station, and sheared off a large number of roofs in its path across the city. Severe winter storms are more common and when accompanied by high winds, can cause extensive damage to city and private property and endanger life. Trees torn or up-rooted by winds are hazardous to surrounding objects, structures and could block transportation routes. Compliance with the Uniform Building Code usually insures that buildings will not be knocked down nor the roofs blown off by excessive winds - except those of tornado force.

Broken power lines or major black-outs caused by any reason are life hazards that must be answered immediately and attended to until the power can be shut off or restored. Power black outs for long periods of time can cause extensive economic losses to all segments of the community from loss of spoiled food by individual families to the loss of production time by business and industry. Black-outs that affect traffic control devices severely limit the ability to move traffic and requires a large commitment city resources. Restoring lost electrical power is dependent upon the Pacific Gas and Electric Company's ability to respond to the outage. PG&E has provided timely responses to past problems but their ability to quickly respond is dependent upon the number and priority of requests for service. In the event of a major storm it is probable there will be power outages in "pockets" of Sunnyvale lasting up to 48 hours.

The undergrounding of power lines reduces the number of power outages resulting from severe weather. Sunnyvale has funded underground projects in the past, most recently along Fremont Avenue between Wolfe Road and Belleville. The city will continue to be served by a mixture of underground and overhead power lines throughout the city. PG&E does not currently have any plans to underground utilities other than what is required for new construction or redevelopment site upgrades.

For more information on PG&E refer to the Lifelines section on page 53.

FIRE HAZARDS

A major responsibility of the City is one of providing an environment protected from the ravages of fire that can threaten the lives and property of the community's citizens and businesses. A variety of factors determine the number and type of fire service demands. Chief among them are the age, size and general condition of the community and its infrastructure, type of construction and building uses, nature of major industries, extent of local regulations and policies concerning fire and life safety measures and the ability and willingness of city government to meet community expectations and mandated requirements concerning levels of service.

Since the writing of the 1984 Sub-Element Sunnyvale has made several significant changes in local ordinances law to mitigate the hazards from fires. The goals of these ordinances are to reduce the number of deaths/injuries and

provide a hgher level of protection against property damage from fires. In 1987 Sunnyvale adopted a new ordinance requiring automatic sprinkler systems to be installed in all new residential construction. For many years automatic sprinkler systems have proved their value in commercial and apartment buildings but have not been required for residential structures. Sprinkler systems for residential dwellings are also required when adding on or remodeling over 50% of the building. Additionally, smoke detectors are now required for residential dwellings. Smoke detectors have been credited with saving many lives by warning residents to escape during the early stages of a fire. One of the quickest ways for a fire to spread to other structures is by burning embers blown by the wind onto wood roofs of adjacent dwellings. To combat this common problem the city adopted a fire resistant roof ordinance in 1988. It requires roofs for new residential construction to be of "fire retardant" materials, as defined by the Uniform Fire Code. Generally, replacement roofs for residential living units must be "fire resistive" when more than 25% of the existing roof is replaced. It is impossible to know how many lives are saved or how many fewer dollars in property damage are done because of these laws but the evidence from fire cause investigations overwhelming proves that they will help meet these two goals.

When viewed as a whole, the balance of factors in Sunnyvale is favorable and past fire experience has demonstrated Sunnyvale to be a relatively fire safe community. Master planning has emphasized fire prevention through a comprehensive review of building plans and ongoing periodic inspections of occupied businesses, engineered fire protection systems and fire safety education as methods to maintain a relatively low loss of life and property due to fires.

However, as in any city, the potential for serious fire events is ever present. A trained and well-equipped fire service must be ready to respond not only to fires, but to medical aid calls, hazardous materials incidents and other situations requiring particular expertise. While the potential for extraordinary disaster always exists, and while the aging process of the City and its buildings will have some adverse impact on fire loss, the overall environment is comparatively fire safe.

For more detailed information refer to the Fire Services Sub-Element which is part of the Public Safety Element of the General Plan. The goals, policies and action statements related to fire hazards are listed in the Fire Services Sub-Element.

HAZARDOUS MATERIALS

Since 1950, Sunnyvale's growth has been closely tied with the evolution of high technology industries. Many of the processes used in these industries involve hazardous, toxic substances. In the early years of the semiconductor industry the use of these substances grew faster than the technology to control and lessen their potential risks. There is still uncertainty as to the ultimate impact that toxic substances will have on the environment. Assessment of the potential dangers posed by hazardous substances involves the identification of the sites utilized for their production, storage, use and/or disposal. It also involves the identification of the methods and routes used for transportation. This information can then be used to measure levels of risk to the community.

Two categories of risk can be broadly defined as "higher hazard" sites and "moderate hazard" sites. The higher hazard sites are those that store and use hazardous materials in large volume or that have the potential of significantly affecting the surrounding community if spills/accidents occur, releasing toxic substances. The greatest threat to community safety is an accidental discharge of toxic gas into the outside air. Moderate hazard sites pose less of an immediate threat to the community because they either use smaller quantities of hazardous materials, the storage is underground and/or the substance is less toxic. Local gas stations are examples of moderate hazard sites. All high hazard and 75% of all moderate hazard uses are located north of the Southern Pacific Railroad right of way.

There are many ways the community is impacted by hazardous materials. For example, old style single wall construction underground storage tanks (illegal to install today) frequently leaked after they had been in the ground for several years. It was first thought that thick layered clay, such as in Santa Clara Valley, was impermeable to most substances and provided a high degree of protection for the deep aquifer. More recently however, scientists have discovered that many of the substances used today can migrate through porous zones of the clay and seep into the fresh water aquifers. This process can be accelerated by the presence of deep holes and wells breaking the layers of clay and acting as a pipeline for the toxic chemicals. As of July, 1993, Sunnyvale has 179 sites (134 petroleum fuel & 45 toxic materials) with underground contamination. The State Water Resources Control Board maintains an inventory of all ground contamination sites. The Regional Water Quality Control Board has the responsibility to ensure the clean up of these sites. However, because of our local interest, Sunnyvale's Fire Prevention Bureau monitors progress of the underground cleanup and provides input and/or assistance as needed. Clean up of those sites that have released hazardous materials is an ongoing process.

Another example is the risk of hazardous materials spills during major seismic events. Bottles falling to the ground may break and release hazardous substances. Containers could be broken by ground movement, falling storage shelves or improperly secured equipment. There is also the risk of leaks from aboveground and underground pipes rupturing, causing the release of toxic gas or liquids.

Regulation and Controls

The realization that the "clean industries" of 20-30 years ago use hazardous materials has drawn nationwide pressure to lessen the level of exposure to toxic substances. Public recognition of the hazards and the level of risk involved in the use, storage, handling and disposal of hazardous materials has increased the interest for more knowledge of these substances and pressure for tighter controls. A myriad of regulations exist on the federal and state level addressing the production, transportation, and disposal of hazardous materials. However, enforcement of regulations at the site of use is primarily a local issue. In the last several years Sunnyvale has passed several ordinances regulating hazardous materials. These ordinances have attempted to meet the safety needs of the community while not burdening industry with unnecessary constraints and regulations.

The city was instrumental in the development of the model Hazardous Materials Storage Ordinance proposed by the Santa Clara County Fire Chiefs' Association. It was adopted by the city in April, 1983. This ordinance enacted Title 20 of the Municipal Code, and regulated aboveground and underground storage of hazardous materials and waste. In 1990 new state legislation required changes in the city's underground storage regulations. As a result of this mandate Title 21 of the Municipal Code was enacted to include all of the regulations dealing with underground storage. As required by the 1983 ordinance, the Fire Prevention Bureau completed a survey of Sunnyvale businesses that have underground hazardous materials storage facilities. This survey identified the locations and the hazardous materials in the underground storage tanks. All underground hazardous materials storage facilities are monitored to detect any leaks from tank systems.

In 1986, AB 2984 (Tanner) was passed, establishing a process for the development of hazardous waste management plans for all California counties, regional councils of government and the state. In 1989 Sunnyvale participated with other Santa Clara County cities in developing the Hazardous Waste Management Plan (CHWMP). This plan was subsequently approved by the County Board of Supervisors and the City Councils of every participating city, including Sunnyvale. In addition to becoming the County Plan, the CHWMP was designed as a plan which could be adopted by participating cities for their own use. The City of Sunnyvale has adopted the CHWMP as the policy document and planning guide to guide all decisions regarding the development of all off-site hazardous waste management facilities and all programs related to the management of hazardous waste within the City. The CHWMP proposes strategies for implementing hazardous waste reduction, treatment and disposal in the county. Although the CHWMP is county wide in scope, these strategies can and should be implemented by the City as well.

To reduce potential hazards from the use of toxic gasses the city passed the model Toxic Gas Ordinance in 1990 (Municipal Code Chapter 16.53). This ordinance requires engineering controls to reduce the likelihood of the off-site release of toxic gasses. A seismic detector that will shut off the gas flow in the event of an major earthquake is one of the controls required. The ordinance also provides for the treating of toxic gases in normal operations and also during emergencies.

The ordinances passed in 1983 and 1990 required businesses to obtain permits for the storage and handling of hazardous materials. The Public Safety Department's Fire Prevention Bureau issues the hazardous materials storage and toxic gas permits to businesses who use these substances. As of July, 1993, 659 businesses have permits for the storage of hazardous materials and 25 businesses have permits for the use of toxic gasses. The types and quantities of hazardous materials stored and used at Sunnyvale businesses varies from gasoline in underground storage tanks at the corner gas station to high-tech computer businesses' use of toxic gasses in the manufacturing of computer chips. All of these facilities are inspected annually by Fire Prevention Bureau Hazardous Materials Inspectors.

Response to Hazardous Materials Incidents

Due to the increased use of hazardous materials Sunnyvale has substantially increased its planning, enforcement and incident response efforts to effectively deal with these hazards. The 1982 implementation of the Public Safety Department's Hazardous Materials Response Team was the first of its kind in Santa Clara County. It included the purchase of a new multi-purpose fire apparatus and the additional staffing of 2 Public Safety Officers for hazardous materials and other firefighting responses. The officers assigned to the Hazardous Materials Response team receive 7 weeks of specialized training. The number of hazardous materials spill incidents has declined from 110 in FY 88/89 to 32 in FY 92/93. The reasons for the reduced number of hazardous materials accidents include the tighter regulations and controls of hazardous materials as well as the increased awareness and knowledge of hazardous materials handlers in the business community.

AVIATION HAZARDS

In 1991, the federal Base Closure and Realignment Commission recommended transfer of Moffett Field NAS to NASA Ames Research Center. This recommendation was subsequently approved by the President and Congress. The Navy will officially depart on July 31, 1994. NASA will officially become the operator of Moffett Field on September 1, 1994. NASA has stated that they intend to operate the airfield at a level which does not exceed the level of operations by the Navy. Moffett Field will continue to support the operations of NASA, the Air Force, Army, Air National Guard, Navy Reserve activities and Silicon Valley's high technology industry.

Compatible land uses for and around Moffett Field have been the subject of intense debate for many years. Other than the potential of aircraft accidents, noise is the most significant concern of area residents. After the April 12, 1973 mid-air collision of a Navy P3 Orion and a NASA 727 jet the Department of Defense directed a study to analyze the land use compatibility surrounding Moffett Field. It designated areas (zones) that may not be suitable for certain types of development based on noise levels and accident potential. These zones were labeled Air Installation Compatible Use Zones (AICUZ). The study was updated in March of 1982 to incorporate a new noise contour (a land area affected by noise from aircraft operations).

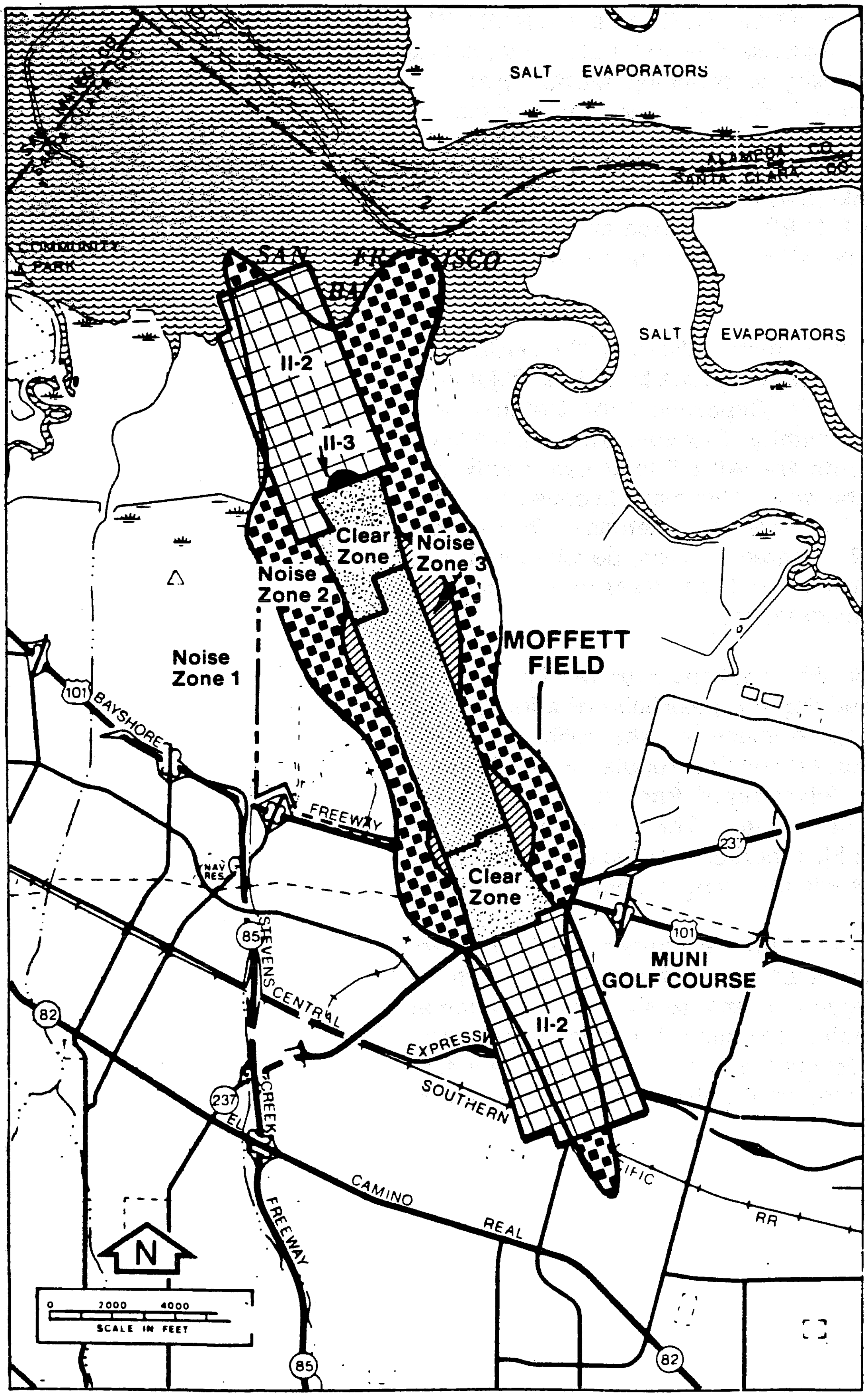
Figure 8, page 45, is a map indicating the AICUZ for Moffett Field. Figure 9, page 46, is a Land Use Objectives Matrix developed by the Department of Defense and adopted by the Community Development Department. There are conflicts with the AICUZ land use matrix and present land use in the city. These are because the uses were existing long before the Defense Department instituted the AICUZ program. New development and redevelopment proposals in these areas must take the AICUZ study into consideration.

NASA, in anticipation of its takeover of Moffett Field in 1994, is currently studying the possibility of adopting the civil FAA Regulations in place of the military AICUZ standards. If NASA adopts the FAA regulation (14 CFR 77) it would increase the "clear zone" from 750 feet to 1000 feet to each side of the runway. This increase would still be within the Moffett Field borders. If the change is made it is not anticipated it will have any impact on Sunnyvale.

Since the announcement of the departure of the Navy there has been an increase in proposals by other jurisdictions requesting the federal government to allow civil aviation at Moffett Field in addition to the current aviation users. Any increase in use by federal tenants and/or civil aviation would substantially increase the risk of aircraft accidents, noise and air pollution.

Moffett Field AICUZ Map

FIGURE 8



750' to each side of the runway centerlines

3,000' from end of runways

Accident Potential Zone II
Noise Zone 3

Accident Potential Zone II
Noise Zone 2

Accident Potential Zone II
Noise Zone 1

Noise Zone 3
(75+ CNEL)

Noise Zone 2
(65-75 CNEL)

FIGURE 9

Land Use Objectives Matrix - Moffett Field Area

This chart is a combination of the Community Development Department's recommended compatible land uses for Moffett Field's Noise and Accident Potential Zones. The areas within the highest Noise and Accident Potential Zones have the most restrictive land use guidelines. Refer to the Moffett Field AICUZ Map on previous page.

LEGEND: APZ = Accident Potential Zone NZ = Noise Zone
CA = Clearly Acceptable NA = Normally Acceptable NU = Normally Unacceptable CU = Clearly Unacceptable

Land Use Category		AICUZ Zones in Sunnyvale			
		Clear Zone	APZ II NZ 2	APZ II NZ 1	NZ 2
Residential	Single-Family Dwelling	CU	NU	NU	NU
	Multiple-Family Dwelling	CU	CU	CU	NU
	Mobile Homes	CU	NU	NU	NU
	Transient Lodging	CU	NU	NU	NU
Commercial	Wholesale Trade	CU	NA	NA	NA
	Retail Trade	CU	NA	NA	NA
	Eating & Drinking Places, Theaters	CU	NU	NU	NA
	Personal and Business Services	CU	NA	NA	NA
Industrial	Food, Processing, Textile Mill Prod.	CU	NA	NA	NA
	Research, Electronics, Plastic Prod.	CU	NU	NU	NA
	Other Indus. Manufacturing Prod.	CU	NA	NA	NA
	Chemicals, Petroleum Refining	CU	NU	NU	NA
	Salt Ponds	NA	CA	CA	CA
Public Services	Government Services	CU	NU	NA	NU
	Educational, Health Services	CU	CU	CU	NU
	Culteral Activities, Churches	CU	NU	NU	NU
Transportation	Roadways, Rail Lines	CU	CA	CA	CA
	Port Facilities	CU	CA	CA	CA
Utilities	Gas, Electric, Telephone, etc.	CU	CA	CA	CA
Outdoor Recreation	Playgrounds, Neighborhoods, Parks	CU	NA	CA	NA
	Community, Regional Parks	CU	NA	CA	NA
	Sporting, Entertainment Assembly	CU	NU	NU	NU
	Water-Related Activities	CU	NA	CA	NA
	Open Space/Trails	NA	CA	CA	CA